Simulation of Temperature and Moisture Profile of Single Mung Bean Grain under Infrared Radiation

M. Meenu[1], S. Gill[2], P. Guha[3], S. Mishra[4]

1. AcSIR Ph.D. Scholar, Agrionics division, CSIR-CSIO, Sector 30C, Chandigarh, India, 160030
2. B.Tech. in Engineering Physics, Indian Institute of Technology, Delhi, India, 110016
3. Scientist, Agrionics division, CSIR-CSIO, Sector 30C, Chandigarh, India,160030
4. Principal Scientist, H1 division, CSIR-CSIO, Sector 30C, Chandigarh, India, 160030

Introduction: Drying of grains is an important postharvest operation. Infrared (IR) drying is advantageous over the conventional drying methods. In this study, COMSOL MULTIPHYSICS ver.4.3b is used to study the temperature profile and the moisture change of mung bean under IR over a period of time and simulation results were compared with the experimental data.

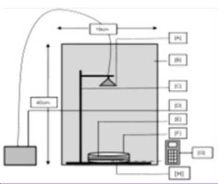

Figure 1. Laboratory scale infrared heating setup

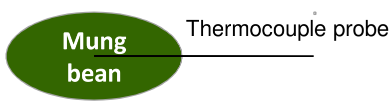

Figure 2. Thermocouple probe inserted in mung bean

Computational Methods: 'Heat transfer in Solids' and 'Transport through diluted species' were used to develop a model of temperature and moisture content of a mung bean. The mathematical equations solved using finite element method.

$$\frac{dM}{dT} = \nabla .(D(T)\nabla M)$$

$$\frac{\rho Cp(M)dT}{dT} = \nabla .(Kp(M)\nabla T)$$

$$\frac{\rho CpdT}{dt} + \rho Cp\,\mu .\nabla T = \nabla .(K\Delta t) + Q$$

No slip boundary condition is valid throughout the grain. The boundary of the grain is assumed to be continuous.

For boundary 1: Inward heat flux =150W/m^2

For boundry 2: Q_o=0 , T= 300K

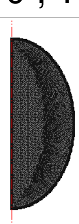

Figure 3. Mesh geometry of mung bean

Results: After heating the grain for 10mins maximum temperature of 61.93ºC was observed. However, with simulation maximum temperature of 62.85ºC was observed. After 10mins, a significant reduction in moisture content was also observed. The same trend was also observed with the theoretically simulated data.

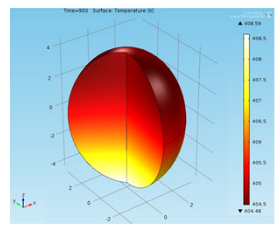

Figure 4. 3D Temperature profile of single grain

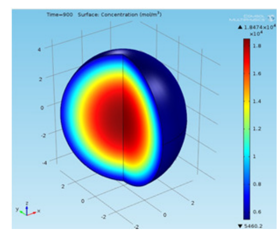

Figure 5. 3D Moisture profile of single grain

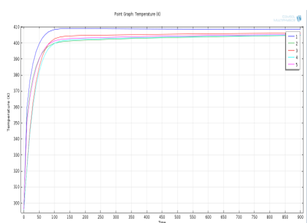

Figure 6. 2D temperature graph

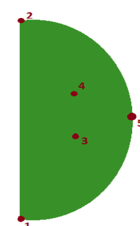

Figure 7. Points for temperature profile

Conclusions: The theoretical predictions of moisture and temperature profiles inside the grain were verified by experimental data. The present finding can be useful for the prediction of temperature and moisture profile of grain being dried using commercial IR dryers.

References:

1. ElGamal et al, Coupling CFD and Diffusion Models for Analyzing the Convective Drying Behavior of a Single Rice Kernel, Drying Technology, 32, 311–320 (2014)
2. Ravikanth et al, Measurement of thermal properties of mung bean (*Vigna radiata*), Transactions of the ASABE, 55(6), 2245-2250 (2012)

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